

Symposium focuses on key role  
of electron transfer in chemistry  
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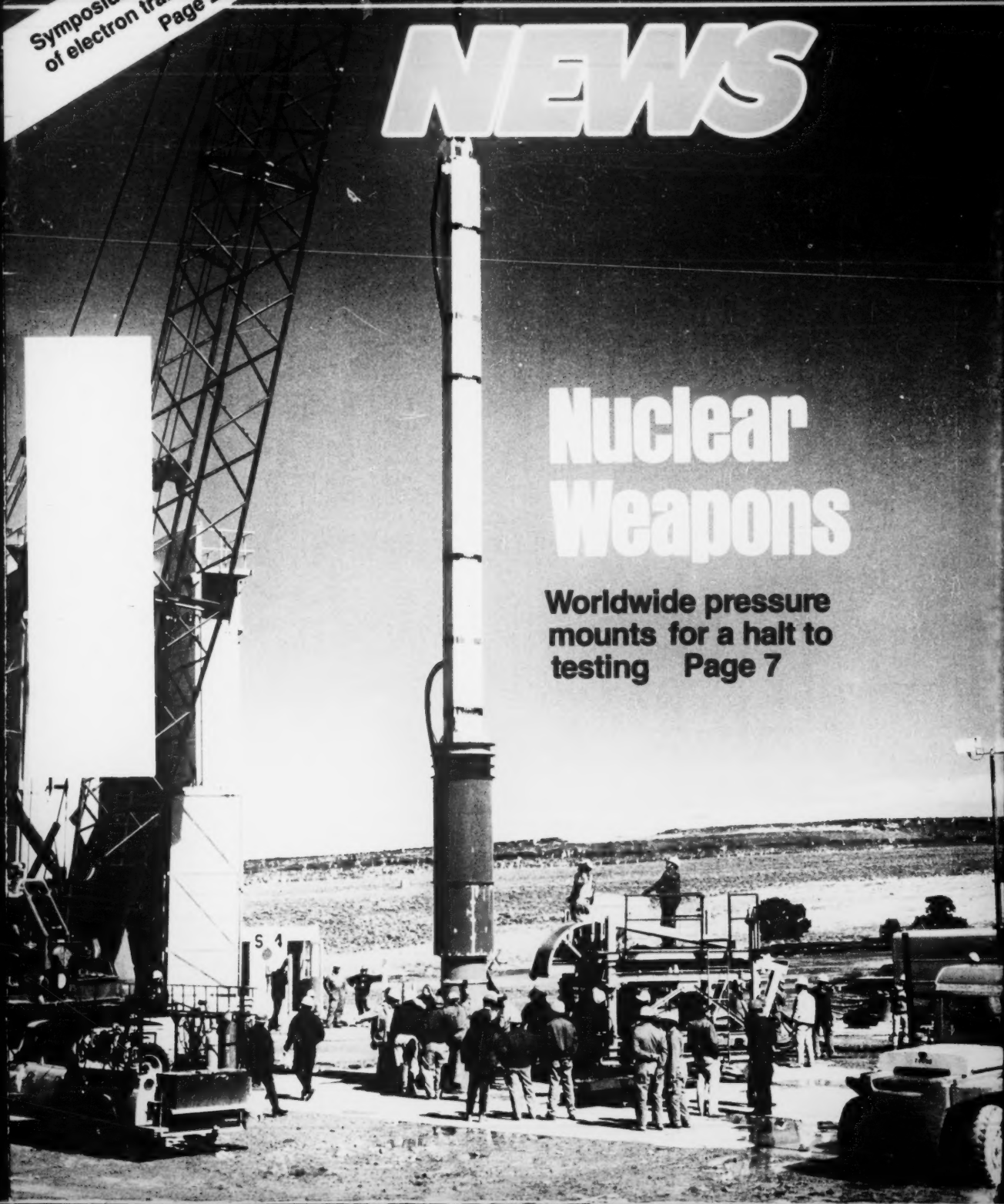
OCTOBER 8, 1990

CHEMICAL & ENGINEERING

# NEWS

## Nuclear Weapons

Worldwide pressure  
mounts for a halt to  
testing Page 7



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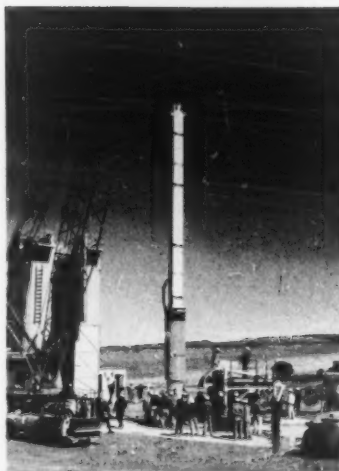
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Cover: Workers prepare to test nuclear weapon at government's Yucca Flat, Nev., testing site. Photo courtesy of Department of Energy

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## Chemical & Engineering News

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## LETTERS

### Science education

The report, "Winds of Revolution Sweep through Science Education" (C&EN, June 11, page 27), is excellent, but the major restructurings reported are at best a good beginning. The problems of education cannot be solved to any degree just by change in the classroom, as it is only one variable. There are others, the most important of which is the cluster of attitudes that American society has about education. These attitudes are so important that, if they are not changed, they will substantially reduce the effect of other changes.

This is not to say that we should not go ahead with restructurings. But there needs to be a simultaneous effort to upgrade the perceived value of education. This is the biggest advantage that the Japanese have. They think education is important. Few Americans do to the extent that the Japanese do.

E. G. Sherburne Jr.

President, Science Service  
Washington, D.C.

### Thermodynamic equation

My purpose in writing this letter is to describe some fun I had with a thermodynamic equation after it was reported (C&EN, Oct. 9, 1989, page 23) that Spectra brand polyethylene melts at 147 °C, "which cannot be significantly improved because it is an inherent property."

Years ago I was interested in relating the solubility of the highly *n*-paraffinic waxes present in No. 2 diesel and domestic burner fuels to the total composition of these fuels. Upon cooling, these fuels solidify when only a small amount of wax has precipitated, unless a wax modifier is present. I assumed that these fuels were essentially ideal solutions of *n*-paraffin mixtures in liquid hydrocarbon solvent phases, and that enthalpy and entropy of fusion of the precipitating wax were linear functions of the number average molecular weight of the *n*-paraffins in this wax. (For individual *n*-paraffins, enthalpy and entropy of fusion are linear functions of molecular weight.)

Thus:

$$\log W = a + bM + (c + dM)/T$$

Here *W* is the mole fraction of *n*-paraffins of *M* number average molecular weight present in a fuel with an observed wax cloud point of *T* degrees absolute. Fuels were studied in sets of four to evaluate constants *a*, *b*, *c*, and *d* in simultaneous equations. *M* was calculated from gas chromatography analysis of the

wax filtered off at about 20 °C below the cloud point, and the molecular weight of the liquid phase (filtrate) was obtained by any of the usual methods, such as ebulliometry. It was found that the assumptions were tenable and that:

$$\log W = 2.63449 + 2.48608 \times 10^{-2}M - 10.4107M/T$$

(These constants provide for a change from natural logarithms to base 10, and the gas constant *R* is included in the last term. Dimensions will be obvious. Constant *c* was so small that it could be set equal to zero.)

This equation was found to work for petroleum hydrocarbon fuels varying widely in composition and properties.

But this is not the point of my letter.

I applied this equation to polyethylene resin by letting *W* = 1, ( $\log W = 0$ ) and dividing by *M* (letting *M* = ∞). At *M* = ∞, *T* will be the highest melting point possible as predicted by this equation.

$$\begin{aligned} \log W/M &= 2.63449/M + 2.48608 \\ &\times 10^{-2}M/M - 10.4107M/MT \\ 0 &= 0.00000 + 2.48608 \\ &\times 10^{-2} - 10.4107/T \end{aligned}$$

$$\text{Solving: } T = 418.8 \text{ K, or } T = 145.6 \text{ }^{\circ}\text{C}$$

The value of 147 °C must have been calculated in some similar way, but it seems unreasonable to expect an extrapolation to work from several chemically rather untidy, low molecular weight (200 to 400), dilute solutions, all the way up to a pure, very high molecular weight (1,000,000 to 5,000,000), highly crystalline solid. But it does work rather well. To those who are more adept at thermodynamics than I, it may be obvious that the limiting melting point of polyethylene should be given by the ratio of constant *d* to constant *b*, but this was an exciting discovery for me.

Perhaps more recent generations of chemists prefer more sophisticated types of investigation, but I am not apologetic about my enthusiasm for the type just described. This kind of discovery every once in a while made my work as a chemist interesting and worthwhile.

Scientists cannot have complete control over their opportunities for creativity and invention, and there is not always provision for subsequent monetary bonuses for success in these areas. However, I am convinced that anyone who likes math and science is sure to find such opportunities in chemistry. There will be rewards, and each opportunity will be an important part of these rewards.

William C. Hollyday Jr.  
Watchung, N.J.

# Canadian Firms May Reap Uneven Benefits from EC's 1992 Plan

**Biotech, generic drug, and specialty chemicals industries likely to be among winners but commodity chemicals, others may struggle to hold steady**

Earl V. Anderson,  
C&EN Northeast News Bureau

The European Community's sweeping plan to remove internal trade barriers among member countries and to create a harmonized European market by the end of 1992 will lead to the largest single integrated market in the world. It will have an impact on Canadian chemical companies, just as it will on every other chemical firm inside and outside the EC.

But the impact will not fall equally on all Canadian chemical companies. Some may benefit, and others may be hurt, depending on each company's circumstances.

That, at least, is the gist of a report recently issued by the government agency, External Affairs & International Trade Canada. The report, "1992 Implications of a Single European Market," covers chemicals, new materials, pharmaceuticals, and biotechnology. It is one of several EAITC has issued on the EC's 1992 plan over the past year and a half.

The products—and the companies—that the EAITC report covers are extremely diverse. Nevertheless, say its authors, they have been able to develop some general conclusions. For instance, how well many Canadian chemical companies will be able to exploit the opportunities that the European market will provide may well be linked to how successfully they have responded to the opportunities provided by the Canada-U.S. free trade agreement. Those chemical companies that have increased their scale of operations to take advantage of markets in the U.S. as well as in Canada probably

will find it easier to crack the new European market.

Much will depend, too, upon whether a Canadian chemical company already does business in Europe and whether that business involves direct investment or exports. Even those companies that do not trade with Europe now will feel the sting of a united European market. That's because, as European competitors become stronger from the growth that a single European market is expected to create, they will use their newfound strength to expand into other markets, including those in North America.

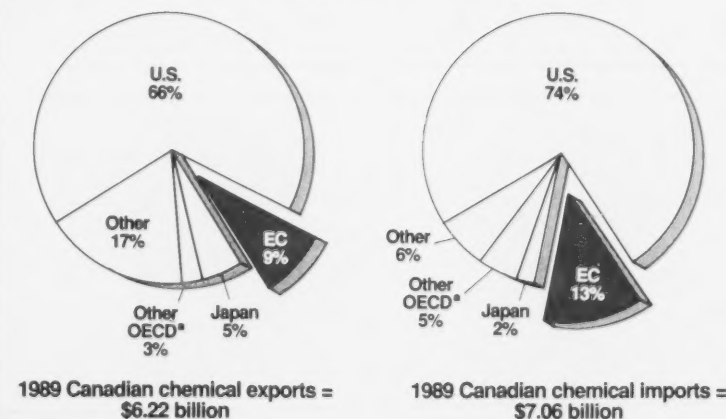
Right now, Canada's biggest chemical trading partner is the U.S. The EC is not much of a factor. Last year, Canada exported \$6.2 billion worth of chemicals (at current exchange rates). Two thirds of that went to the U.S. Only \$544 million worth, or 8.7%, was shipped to the EC. Even Asia, including Japan, is a much more important market for Canadian chemical exports.

But that 8.7% average can be misleading. For some chemical categories—particularly for synthetic rubber, plastics, and plastics products—exports to the EC are a much lower percentage of the total. Canadian chemical exports that far exceed the average include organic chemicals, at 16.3%.

The story is the same for Canadian chemical imports. Canada imported slightly more than \$7 billion in chemicals last year, with almost 74% of it coming from the U.S. The EC shipped only \$938 million worth of chemicals to Canada, or about 13% of Canada's total chemical imports.

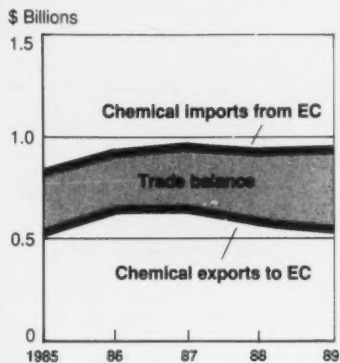
For some chemical products, however, the EC is a significant supplier to Canada. For instance, a hefty 49% of Canada's dye imports came from

**Canadian trade with European Community is small**



\* Members of the Organization for Economic Cooperation & Development, except the U.S., Japan, and members of the EC.  
Source: Statistics Canada

## Canada's chemical trade deficit with EC persists



Source: Statistics Canada

the EC last year, as did almost 30% of Canada's imports of pigments, "lakes," and toners. The EC also accounted for 22% of the country's organic chemical imports.

The large commodity chemical firms operating in Canada, such as Nova, Dow Chemical, Du Pont, Union Carbide, and ICI, all have plants in the EC. So do some of the large multinational pharmaceutical companies, such as American Home Products, Merck Frosst, and Johnson & Johnson. Because their EC subsidiaries qualify as "EC companies," they are likely to benefit directly from the more liberal trade conditions of the new European market. Many multinational chemical companies in Canada note, for instance, that the integrated EC likely will make it easier for them to move products across country borders within the EC. Packaging and labeling requirements also are likely to be simplified.

Certainly those Canadian companies with EC subsidiaries probably will benefit more from the EC plan than the firms that only export to the EC, says EAITC. One reason: They will have better access to information about their markets. And they will be in a better position to influence EC product standards and other EC policy matters.

Exactly how much the Canadian subsidiaries of the large commodity multinationals will benefit depends on the decisions their multinational parents make. It is they who will de-

cide how much of their EC market requirements will be produced in Canada. It is they who will decide how much will be produced in the EC—or somewhere else.

For the commodity chemicals producer in Canada, EAITC doesn't expect a more unified European market to yield dramatic improvements. Much of the feedstock and energy advantages that Canadian producers once had have evaporated (although the Mideast crisis could quickly reverse this). Meanwhile, these companies are still adapting to the U.S.-Canada free trade agreement and the larger U.S. market that it brings. This will command their attention for some time yet.

The Pacific Rim also has become a much more important export market for these companies, and it could become even more important. Even within Canada, some important chemical markets are growing and could loom more important than the EC market. The pulp and paper industry is one example.

Consequently, Canadian producers of commodity chemicals probably won't be hurt by the upcoming market in Europe. They may even benefit a little. But the 1992 plan won't divert much of Canada's commodity chemical trade to Europe. Canadian producers enjoy a bigger advantage in other world markets.

The specialty chemicals segment of the Canadian industry, however, may find more opportunities for profitable niches from the European 1992 plan than its present weakness suggests. Certainly it faces many obstacles. Canada runs a massive trade deficit in specialties. European chemical firms are very strong international competitors, and they continue to invest heavily in specialties. Because of Canada's relatively weak pharmaceutical industry, fine chemicals production is negligible. There's little incentive to develop a larger production base. However, things could change for Canada's specialty chemical producers. The trade agreement with the U.S. may make it possible for them to increase their scale of operations and, in the process, become stronger international competitors. Although they are few, some already do sell in Europe. And a few multinationals al-

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## Business

ready have given the go-ahead to their Canadian subsidiaries to produce specialties for world markets. Du Pont Canada's specialty resins are an example.

Canada, says EAITC, has two advantages that could aid the specialty chemicals sector. First, raw material costs generally are low. And Canada has plenty of space for potential plant sites. This could entice European companies to invest in Canada and, under the trade agreement with the U.S., gain tariff-free access to the U.S. market.

The same holds true for advanced materials. With few exceptions, the Canadian plastics products industry is weak. Activity in composites, laminates, and ceramics is modest. In advanced materials, other countries have the technological edge. With very few Canadian companies positioned to exploit the advantages offered by a more unified EC, Canada's best bet lies in attracting European—and other foreign—investment in advanced industrial materials. Foreign investment already is in place in the Canadian pharmaceutical industry. But that doesn't mean the industry will be able to reap some of the advantages that are sure to come as the EC moves toward harmonized product standards and licensing procedures.

Most of the companies in the Canadian pharmaceutical industry are subsidiaries of U.S. and European multinationals. For the most part, they perform modest processing operations. The parent companies already are on the scene in Europe.

If top management assigns world-scale production of some products to the Canadian subsidiaries, Canada could benefit. However, most Canadian pharmaceutical branch plants are small. Many are old and labor-intensive. As a result, there are likely to be few production mandates from multinational headquarters.

The other part of the Canadian pharmaceutical industry—the generic drug manufacturers—could stand to benefit somewhat. Canadian companies have a lot of experi-

## EC receives less than 9% of Canadian chemical exports

| \$ Millions*                         | 1989 Canadian chemical exports |                |             |
|--------------------------------------|--------------------------------|----------------|-------------|
|                                      | Total                          | To EC          | % EC        |
| Chemical elements                    | \$ 174.8                       | \$ 29.9        | 17.1%       |
| Other inorganics                     | 1141.7                         | 96.5           | 8.5         |
| Organics                             | 1582.0                         | 258.2          | 16.3        |
| Fertilizer & fertilizer materials    | 1269.5                         | 56.5           | 4.5         |
| Synthetic rubber & plastic materials | 1206.6                         | 57.0           | 4.7         |
| Plastic basic shapes & forms         | 414.4                          | 8.8            | 2.1         |
| Other chemicals                      | 434.0                          | 37.2           | 8.6         |
| <b>TOTAL</b>                         | <b>\$6223.0</b>                | <b>\$544.1</b> | <b>8.7%</b> |

\* U.S. dollars, converted from Canadian dollars at current exchange rates (\$1.00 U.S. = \$1.154 Canadian). Source: Statistics Canada

ence in generic drugs. As patents expire, this experience could help them take advantage of the European situation by increasing their exports to Europe or by attracting European investment to Canada.

However, even after the 1992 plan takes effect, European licensing procedures may remain too cumbersome for most Canadian generic drugmakers. Profit margins are low on European generic sales because of the overcapacity that already exists there. For the next several years, says EAITC, Canadian generic drugs will find better markets in other parts of the world. The EC's 1992 plan then promises only modest benefits for Canada's pharmaceutical industry. The possible exception is biotechnology. Canada has several new small but energetic biotechnology firms specializing particularly in vaccines, insulin, and diagnostic kits. And Canada's traditionally strong resource industries give the fledgling Canadian biotechnology companies a head start in applying their trade in those potentially huge markets.

Biotechnology, says EAITC, is a field in which Europe seems to lag. As a result, it expects Canadian biotechnology companies will be big gainers from the EC plan. Their biggest competitors will be U.S. and Japanese companies. But Canadian biotechnology companies are quite capable of exploiting market opportunities in the new Europe after 1992. □

say, £100 per mg, they would be no good for the pharmaceutical researcher. You must find a way of synthesizing [them]."

Dextra has pilot facilities with reactors capable of producing runs of 6 L. As Lawson and Hacking point out, for a pharmaceutical company, 1 g is quite a lot. The company's current projects range from milligram to kilogram scale.

"Other companies have wanted our knowledge rather than our synthesis. For example, they will contract with Dextra for the company's in-house expertise of food rheology or food chemistry, so the activity can be utilized properly, but the product itself can be palatable," says Lawson.

"The thing we hope will make the business grow will be new products, in addition to making specialized products for companies," he adds. "We watch the activities of other companies—they make lots of products, but their lines are unfocused. We're beginning to learn what companies are looking for: both the products they are asking for, and what they might be needing in the way of intermediates."

The two are convinced carbohydrate chemistry is a stepchild research area. "If you talk to companies about proteins, there is enormous interest throughout a company. But if you talk about carbohydrates, there are only little spatters of interest," says Hacking.

One branch of science seems to have outstripped another, they believe. A great deal of knowledge about carbohydrates in human tissue has been discovered by biochemists and immunologists who have worked out the functions of carbohydrates and how to mimic them. "If you could modify this carbohydrate with, say, this modified tail, it could enter the tissue; the tail sticking out could act as a target for a drug," says Lawson. The research imbalance, however, occurs because the analysis "has proceeded as far as it has, but there are not enough chemists trained in synthesizing carbohydrates."

Until that lack is addressed, at least, they see a bright future for Dextra, with its carbohydrates know-how.

Patricia Layman

## Chlor-alkali industry focuses on transition

Pressures on end-use markets, imbalances in chlor-alkali demand, technological innovations, and social responsibility are forces the chlor-alkali industry is now facing. Late last month, at the 2nd World Chlor-Alkali Symposium, entitled "An Industry in Transition," about 600 industry members, customers, and representatives from government and environmental groups from more than 30 countries met in Washington, D.C., to examine the impact on business.

In the hierarchy of chemical production, chlor-alkali ranks near the bottom. As such, chlorine and sodium hydroxide (caustic soda) form the basis of numerous chemical processes. Chlorine, a coproduct in the electrochemical production of sodium hydroxide, is used in many plastics, solvents, chlorofluorocarbons, and other organic chemicals. Most major chemical companies are chlor-alkali producers or consumers, with the market adding up to a few billion dollars per year.

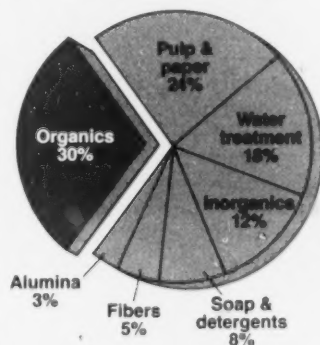
Key issues are those surrounding major chlorine end-use markets such as pulp and paper, water treatment, and polyvinyl chloride production. All such markets are facing environmental and regulatory pressures with an emphasis primarily on the by-products of chlorine use. These include the formation of chlorinated

organics in water treatment and the formation and possible effects of trace amounts of dioxin in pulp and paper bleaching. The impact of plastic packaging, in this case PVC, in solid waste and incineration is raising concern. Other products such as chlorinated solvents and CFCs are targets for elimination, having been identified as environmental or health hazards.

Rather than being moved by traditional economic forces, the industry is facing increasingly aggressive attacks on its products, says J. Roger Hirl, president and chief operating officer of Occidental Chemical. With each of the major market segments that use chlorine in products or processes under pressure to restrict or eliminate its use, he calls the changes faced by the industry a result of "revolution rather than evolution." These pressures are expected to upset an already "precarious market imbalance" between the decreasing demand for chlorine and the increasing demand for caustic soda.

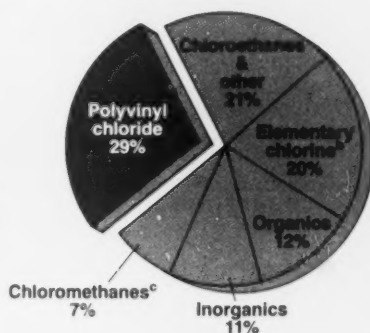
"Survival of the industry is directly linked to the survival of its key markets in what is becoming an increasingly hostile environment for chlorine-based products," says Hirl, requiring industry associations to become more adept at communicating chlorine health, safety, and environmental information. "[The in-

Caustic is used most in organic chemicals...



1989 U.S. consumption = 224 billion lb<sup>a</sup>

...and chlorine most in polyvinyl chloride



1989 U.S. consumption = 22.9 billion lb<sup>a</sup>

<sup>a</sup> Department of Commerce apparent consumption figures. <sup>b</sup> Used in disinfection and pulp and paper. <sup>c</sup> Used in manufacture of chlorofluorocarbons.

dustry] needs to understand and anticipate change in new and innovative ways or ... be swept away with its consequences."

What must be anticipated are dramatic changes in traditional markets via the substitution of other products for chlorine. Although chlorine is the most frequently used disinfectant and is responsible for irradiating many diseases, in water treatment it has been cited in the formation of the suspected carcinogens, trihalomethanes or THMs. To comply with regulations on the release of THMs, most water treatment facilities will consider other options, says Richard Moser, vice president at American Water Works Service Co., Voorhees, N.J. However, replacements to chlorine have trade-offs in cost, effectiveness, and by-products that must be considered.

More stringent and prevalent final regulations, affecting virtually every water treatment facility, are expected to be promulgated by late 1991 or early 1992 with about three years allowed for compliance. Chlorine use may diminish greatly as water utilities discontinue its use, adds Moser.

The pulp and paper industry, while under pressure to reduce its use of chlorine, maintains a need for caustic. Pulp and paper uses about 15% of chlorine produced and about 23% of caustic soda, says Bruce Fleming, director of the chemical pulping and bleaching division of the Pulp & Paper Research Institute of Canada. The shifting balance is expected to affect overall caustic and chlorine prices. Chlorine's share of the world bleaching market will drop from 36% to 26% in the next five years, he predicts, while caustic use will remain essentially constant or even increase.

In North America, chlorine use by the pulp and paper industry is expected to drop precipitously in the next five to six years. Which replacements for chlorine will be used in the bleaching process will depend on government regulations and the quality of paper demanded by consumers. Alternative routes to adjusting the chlorine/caustic ratio in the pulp and paper industry might be found through reduction, replacement, or other sources of caustic soda, Fleming says.

PVC production is often used as a means to counteract the imbalance in caustic/chlorine demand. World PVC production is operating at about 90% capacity, or about 40 billion lb per year, divided equally among major regions of the world. Changes in basic economic conditions such as the price of oil, housing starts (60% of PVC produced is used in construction), and automobile sales will greatly affect the demand for PVC, says Ryoji Endo, managing director of Shin-Etsu Chemical Co., Toyko. In addition, concern over the role of PVC in packaging (about 15% of PVC production worldwide) and its impact on solid waste, is causing some downturn in that market segment.

With growth in PVC demand per capita correlating closely with that of GNP per capita, developing nations will be important factors in the expansion of PVC markets. Growth is expected to be slower in industrialized nations where the market is more mature. Considering all factors, Endo estimates overall growth for PVC at 3 to 5% per year.

Dealing with the imbalance due to stagnating or declining chlorine markets and growing caustic markets will be difficult, concludes Jean Christiaens, managing director of Solvay & Cie. in Brussels. Although chlorine use will not be phased out immediately by the pulp and paper industry, in 10 years it is expected to consume one third of what it did 10 years ago. The production of chlorinated solvents, with nearly half used as raw material for CFCs, will also fall considerably. PVC may be the only market that can sustain growth in chlorine demand.

In contrast, says Christiaens, caustic soda is seeing growth in approximately 70% of its market segments and a decline in only about 10%. As with PVC, correlation between gross national product per capita and caustic consumption per capita indicates room for growth. The traditional cyclic nature of the chlor-alkali industry may have disappeared, he notes, but suggests that shortages and high prices may be avoided in the long term when a new equilibrium between supply and demand develops.

*Ann Thayer*



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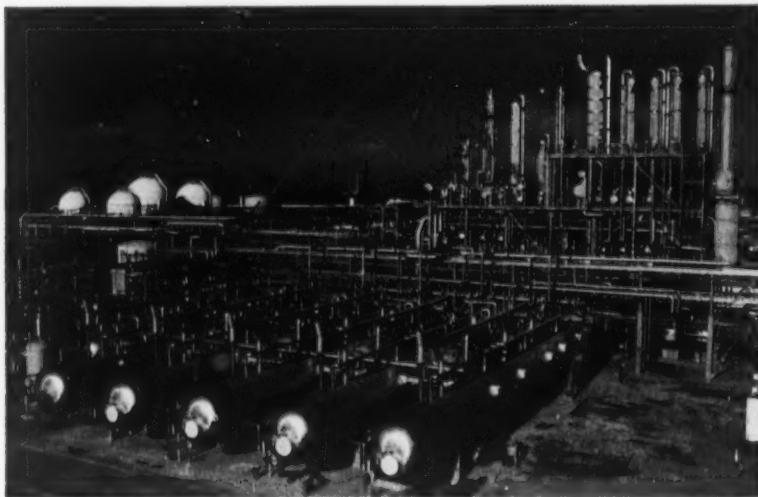
## Demand for $\alpha$ -olefins continues to rise

Linear (or normal)  $\alpha$ -olefins provide a bright growth prospect among large-volume basic chemicals and intermediates. Any economic downturn is expected to cut no more than two points off the annual growth rate of 5 to 7% for the reactive and diversely used  $\alpha$ -olefins during the early part of the 1990s.

Relatively strong growth for these products is a carryover from the mid-1980s when their strong demand spurred all three U.S. producers to add capacity. The most recent capacity addition was at Chevron Chemical, which late last month started up a 250 million lb-per-year unit at its Cedar Bayou, Tex., plant, and celebrated the silver anniversary of the startup of the first commercial-scale unit to make  $\alpha$ -olefins at that location.

That expansion brings Chevron Chemical's  $\alpha$ -olefin nameplate capacity to 500 million lb per year. Company officials at the dedication ceremonies, however, admitted the two units were currently being operated in excess of nameplate capacity. Additional capacity is expected through process improvements.

Also completed during Chevron Chemical's expansion project at Cedar Bayou are additional laboratory facilities, extension of process and quality control systems, and faster



Annual  $\alpha$ -olefins capacity at Chevron's Cedar Bayou, Tex., plant is 500 million lb

and improved loading systems. Dedicated storage capacity has been increased 110,000 barrels and is blanketed to minimize contamination.

Capacity expansions for  $\alpha$ -olefins at Ethyl and Shell Chemical also have been completed recently. Current U.S. nameplate capacity totals more than 2.5 billion lb, and about 300 million lb of 1-butene made as a coproduct with other  $C_4$  hydrocarbons. Capacity expansions are also under way elsewhere such as a new unit for Ethyl in Belgium.

Long-chain olefins, with the unsaturation between carbon atoms other than in the alpha position, also are sold commercially. However, the volumes of these internal olefins are small compared with  $\alpha$ -olefins, the global consumption of which exceeds 2 billion lb per year.

Despite production of  $\alpha$ -olefins in Western Europe and Japan, exports account for more than a quarter of U.S. output. Most of these go to industrialized countries in Europe as well as to Canada, Mexico, Japan, Taiwan, and Venezuela. Besides the olefins, numerous derivatives also are exported.

The largest use of  $\alpha$ -olefins is as a comonomer in making various types of linear low-density and high-density polyethylenes. The majority of these olefins are 1-butene, 1-hexene, and 1-octene. Minor amounts of branched olefins may be used in some polyethylenes. A secondary plastics use is in polybutene. Strong

growth in polyethylene foreshadows that the use of the comonomer will grow at 6 to 7% annually.

After exports (the second largest market for these olefins), the third largest use is in making a wide variety of long-chain alcohols by the oxo process. Most of these alcohols, by reaction with phthalic anhydride, are made into plasticizers for polyvinyl chloride. But these plasticizers have competition from dioctyl phthalate (containing a branched-chain olefin) on a cost and performance basis. Some of the oxo alcohols go into surfactants, as do other  $\alpha$ -olefins that are sulfonated.

Various synthetic lubricants are made of small polymers of  $\alpha$ -olefins. These products and various esters made of synthetic fatty acids from these olefins are used as lubricants and as additives to improve conventional petroleum-based lubricants. They account for more than 10% of consumption.

About 10% of  $\alpha$ -olefins go into a variety of intermediates and end products. Examples include various fatty amines and derivatives for detergents, alkenylsuccinic anhydrides for paper sizing or leather treating, long-chain mercaptans as chemical intermediates, and various epoxides. Some of these specialty chemicals have high growth rates from small-volume bases, but their total demand growth will be about average for all  $\alpha$ -olefins.

Bruce Greek

### Linear $\alpha$ -olefins go to a variety of markets



Forecast 1990 consumption = 1.6 billion lb

<sup>a</sup> Comonomers and polybutene. <sup>b</sup> Mostly plasticizers. <sup>c</sup> Additives and synthetic lubricants. <sup>d</sup> Includes surfactants and germicides. Source: C&EN estimates

# Stepped Up Biomedical Spending on Training, Research Labs Urged

**In spite of current funding squeeze, Institute of Medicine panel calls for channeling more money into training, construction, and equipment**

**Pamela S. Zurer, C&EN Washington**

Sponsors of biomedical research must put more funds into training young scientists and improving research facilities, an Institute of Medicine committee has concluded—even if that means less money for research grants.

Scientists already in despair over the recent dramatic decline in new research grants from the National Institutes of Health, the single largest source of support for biomedical research, may find that message hard to swallow (C&EN, July 16, page 20). But IOM panel chairman Floyd E. Bloom, head of the neuropharmacology department of the Research Institute of Scripps Clinic in La Jolla, Calif., says the current funding squeeze does not justify shortsightedness.

"Unless we as scientists state how we would spend our money for the good of the system over the long run, we can't expect that sponsors would be willing to go along with requests for more money just because things are tight at the moment," Bloom told a recent symposium at the National Academy of Sciences in Washington, D.C. The seminar was held to present the report, "Funding Health Sciences Research: A Strategy to Restore Balance," which IOM's committee on policies for allocating health sciences research funds spent two years putting together.

The panel's goal was to analyze

## **Training should have highest priority**

The Institute of Medicine's committee on policies for allocating health sciences research funds concludes:

- The development of individual career scientists, who contribute through both their own research efforts and by training future scientists, is the most critical and longest term investment in the research system.
- Capital investment in facilities has a slightly shorter expected usefulness to the research enterprise.
- Individual research projects and equipment are generally the shortest and most variable investments over time.

the balance in funding for research projects, training, facilities, and equipment and to recommend any necessary corrections. The committee's task was made tougher by IOM president Samuel O. Thier's stipulation that they could not simply ask for more money.

"It was clear to everyone on our committee that we need more money," Bloom says. "But the goal of the study was to analyze the ways we spend money to see whether we can maximize it so we can guarantee to our sponsors that when more monies are available they will be put to the best use."

Many on the panel were surprised to find that—despite the pervasive gloomy view that biomedical research funding is declining—total U.S. support has been increasing progressively even when inflation is taken into account. In the past few years, however, fewer and fewer grant applications have been successfully funded at NIH because of a combination of factors. These in-

clude increasing numbers of grant applications, higher research project costs, and an increase in the average grant length.

Meanwhile, a larger and larger share of the available funds has been going to support research projects at the expense of training, construction, and equipment—a source of great concern to the committee.

"The system has largely been feeding upon itself in order to maintain the emphasis on ... research projects," Bloom says. "As funds have been dedicated toward R01 [NIH's traditional investigator-initiated research grant] and program project grants, the result has been a progressive diminution in the case of training and an almost total elimination in the case of research facilities construction."

Specifically, although the dollar amounts for NIH training programs have held roughly steady over the past two decades, they have now slipped to about 4% of NIH's extramural budget after accounting for about 18% in 1971. And federal funds for research facilities have been negligible over the past decade except for a limited amount for AIDS.

"In the course of the 1980s, very severe pressures occurred despite rising overall NIH budgets as a result of the explosion of attractive targets of opportunities for current research dollars," says Henry J. Aaron, a panel member who is an economist with the Brookings Institution in Washington, D.C.

As a result, NIH and other organizations "responded in a way that is perfectly natural and rational for a short-term period of stress," Aaron says. "They shifted the emphasis of expenditures from categories that produce relatively long-term pay-offs—specifically buildings and

equipment and training—to fund those activities that produce immediate payoffs—namely support of current research.”

Committee member P. Dennis Smith, professor of biological sciences at Wayne State University in Detroit, explains how the panel's analysis of those trends and of the scientific personnel pipeline led them to worry where the researchers of tomorrow will come from.

“By 1995 we will have a confluence of two unfortunate outcomes,” Smith says. The number of people coming into the pipeline is decreasing because of a decline in the number of high school graduates. At the same time, by 1995 there will be a large attrition from retiring university professors.

The committee decided the distribution of funds across the three broad categories of current research activities, physical capital, and human capital is currently out of balance. It recommends a shift of resources—even within the severe current funding restraints.

“The current pattern is not sustainable,” Aaron says. “A shift in emphasis toward an investment in human and physical capital is necessary for the long-term health of biomedical research. Unless such a shift occurs we will not adequately replenish the stock of trained personnel to carry out research and we will not be giving them adequate research equipment and structures with which to carry out research.”

The committee makes specific recommendations on how NIH's budget might be reallocated over the

next decade under four different budget scenarios—no growth beyond inflation, 2% real annual growth, 4% real annual growth, and a growth rate of greater than 4% a year.

“We felt we must do something to begin to gradually rectify what has occurred over the past 15 years,” Bloom says, “even though we realize the growing problem in funding the number of very valuable research proposals that exist.”

Under the no-real-growth scenario, the committee suggests shifting about \$12 million a year of NIH's extramural budget into training programs until that segment reaches about 7% of the total budget in 2000. For comparison, about 5% of NIH's \$5.6 billion fiscal 1990 budget is set aside for training.

“That would begin to increase the research talent pool at about 400 people a year—still far short of the projected need,” Bloom says. “This is an absolute requirement even under the current tight funding situation.”

Similarly, the construction segment of the NIH budget would grow from roughly 2% in 1990 to about 5% in 2000. As a result of these reallocations, both the absolute dollars and the percentage available for research grants would decrease slightly.

Under the more optimistic scenarios, training and facilities funds would grow faster than funds for research projects, which would grow modestly.

The panel also suggests several pilot projects aimed at easing the pain of researchers who fail to win grant

money. The most controversial proposal involves partially funding grants on a sliding scale.

Under NIH's current grant review system, proposals are awarded a numerical score based on peer review. Monies generally are distributed on an all-or-nothing basis, with grant proposals whose scores fall above the “payline” being funded and the others not.

The sliding-scale experiment would protect proposals that fall just below the payline. Grant applications in the top 10% would get full funding. Those in the next 10% would receive a lower level of funding and the next 10% still less. The scope of the partially funded proposals would be reduced correspondingly, with the NIH study sections (peer-review groups) recommending which parts of the project to focus on.

“We're trying to extend the resources to a greater number of people,” Bloom says, noting that the experiment would result in about 400 more grants being funded this year. The committee also recommends that research institutions be allowed to amortize buildings and equipment more rapidly to reflect that scientific facilities often become obsolete before their physical life has expired. The panel shied away, however, from a full examination of the thorny question of indirect cost calculations, other than to say the whole issue deserves a close look.

The panel also cites a need for better coordination of federal priorities for biomedical research. It proposes that the White House Office of Science & Technology Policy create a health sciences subcommittee to the Federal Coordinating Council for Science, Engineering & Technology. And it suggests formation of a roundtable to promote communication between research institutions, industry, government, and private foundations concerned with biomedical research.

Individual scientists must also work to make sure the system is in balance, the committee says. “Certainly if the scientific community does not come up with its own creative solutions, it's quite clear that Congress is going to impose some solutions on us,” Bloom says. □

### Plan would cut grants to add training and building funds

|                          | 1988          |                | 1989          |                | 1990          |                | 1995          |                | 2000          |                |
|--------------------------|---------------|----------------|---------------|----------------|---------------|----------------|---------------|----------------|---------------|----------------|
|                          | \$ millions   | % <sup>a</sup> | \$ millions   | % <sup>a</sup> | \$ millions   | % <sup>a</sup> | \$ millions   | % <sup>a</sup> | \$ millions   | % <sup>a</sup> |
| Research project grants  | \$3765        | 69%            | \$3828        | 69%            | \$3822        | 68%            | \$3724        | 66%            | \$3640        | 65%            |
| Research centers         | 963           | 18             | 987           | 18             | 998           | 18             | 1026          | 18             | 1054          | 18             |
| Contracts                | 497           | 9              | 507           | 9              | 509           | 9              | 509           | 9              | 509           | 9              |
| Training                 | 239           | 4              | 255           | 4              | 267           | 5              | 323           | 6              | 379           | 7              |
| Construction             | 0             | 0              | 7             | 1              | 14            | 2              | 28            | 5              | 28            | 5              |
| <b>TOTAL<sup>b</sup></b> | <b>\$5463</b> | <b>100%</b>    | <b>\$5583</b> | <b>100%</b>    | <b>\$5611</b> | <b>100%</b>    | <b>\$5611</b> | <b>100%</b>    | <b>\$5611</b> | <b>100%</b>    |

Note: Plan assumes no growth in NIH budget. Totals may not add due to rounding. <sup>a</sup> Percentage of NIH extramural budget. <sup>b</sup> Total NIH extramural budget. Source: Institute of Medicine

# NOTE

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